

ments prior to the great perturbation in this year are determined, and have been already transcribed in *NATURE*; they present a resemblance to those of the first comet which appeared in 1798, about which year Brorsen's comet might have been in perihelion; Dr. Harzer nevertheless expresses the opinion that, although Messier's observations of the comet of 1798 might be open to some degree of uncertainty, it is doubtful whether they would admit of being represented by an elliptical orbit with a short period. He had found the revolution prior to 1842 to be 5'170 years.

THE NAUTICAL ALMANAC.—The volume of this ephemeris for 1887 has been published during the past week, the contents being generally the same as in previous years. The track of the total solar eclipse of August 19 is given in detail for the greater part of the course, and the maximum duration of totality is found to be 3m. 50s., the central eclipse with the sun on the meridian falling in longitude 102° 0' E. and latitude 53° 47' N. The Greenwich list includes four occultations of *Aldebaran* during the year and one of *Regulus*.

The average annual sale of the *Nautical Almanac* during the last five years has exceeded 15,500, though many maritime nations have now their nautical ephemeris.

THE PHILOSOPHICAL SOCIETY OF GLASGOW

THE *Proceedings* for 1882-83, pp. 592, 23 plates, and 3 maps, have just been issued, and contain the following papers:—On insensibility arising from a deficiency of oxygen in the air, by Dr. Wallace, president; on technical education, by David Sandeman and E. M. Dixon, B.Sc.; on the decay of building stones, by Dr. Wallace; on some new infusoria, by William Milne, M.A.; note on Lippmann's capillary electrometer, by Dr. McKendrick; on milk and milk pollution, by Dr. John Dougall; on Struther's process for pulverising diamondiferous ore, by Wallace Fairweather, C.E.; on the use of litmus, methyl orange, phenacetol, and phenolphthalein as indicators, by R. S. Thomson; on approximative photometric measurements of sun, moon, cloudy sky, and electric and other artificial lights, by Sir William Thomson; on the preservation of food by cold, by J. J. Coleman; on the clauses in the Glasgow Police Bill having reference to the prevention and mitigation of disease, by Dr. Ebenezer Duncan; on the ships and shipping trade of Great Britain, by N. Dunlop; on the iron ore industry of the north of Spain, by J. J. Jenkins; on the use of rosolic acid as an indicator, with additional notes on phenolphthalein and methyl orange, by R. S. Thomson; on architecture in Glasgow, by J. Sellars, jun., I.A.; on the water highways of the interior of Africa, with notes on slave hunting and the means of its suppression, by James Stevenson, F.R.G.S.; on a new seismograph, by Thomas Gray, B.Sc.; on the fertilisation of flowers, by Rev. A. S. Wilson, M.A.; on algin, a substance obtained from some of the commoner species of marine algæ, by E. C. C. Stanford; on chemical industries, by R. R. Tatlock; on nitroglycerine, dynamite, and blasting gelatine, by George McRoberts, manager of the Works of Nobel's Explosives Company; on the action of heat and the chlorides of phosphorus upon the water salts of hypophosphorus, phosphorus, and phosphoric acids, by Dr. Otto Richter; on a volumetric process for the estimation of cobalt and nickel, by Dr. John Clark; and, on the development and generic relations of the corals of the carboniferous system of Scotland, by James Thomson, F.G.S.

The society has at present 19 honorary, 10 corresponding, and nearly 700 ordinary members, and is about to enter on its eighty-first session. In addition to the ordinary meetings of the society, held fortnightly, there are sections for architecture, biology, chemistry, sanitary science and social economics, and geography and ethnology.

RESEARCHES ON SPARK SPECTRA

The Disappearance of Short Lines

IT was shown in a former Report of this Committee (Southampton meeting) that the spectra of metallic solutions were the same as those from metallic electrodes line for line, even short and weak lines being reproduced. The principal difference observ-

¹ Report of the Committee on the Comparison of the Spark Spectra of the Elements with Spectra of Solutions of their Compounds, drawn up by Prof. W. N. Hartley.

able in the two spectra was a lengthening of the short lines when spectra were taken from solutions, so that discontinuous lines became long or continuous lines. A few instances of short lines disappearing have also been noticed, but such disappearances occur only when the lines are so short, mere dots, in fact, that no solution can contain a quantity of the metal sufficient to yield an image of them. Certain very short lines in the spectrum of metallic zinc are an example of this. Very short lines in the spectrum of aluminium were not reproduced by solutions of the chlorides except when the solutions were very strong, and then they always appeared. It may thus be seen that the quantity of metal present in the compound determines the presence of these lines.

The Lengthening of Short Lines.—It was remarked that in certain cases metallic electrodes showed a different spectrum according to whether the spark was passed between dry or wet electrodes. Thus it was pointed out that when iridium electrodes are moistened with calcic chloride, discontinuous lines which are very numerous in this spectrum become continuous; and on further examination into this matter it has been found that even moistening with water has the same effect. Hence the supposition, of which there seemed some possibility but no proof, that a chloride of the metal was formed is found to be untenable. The very short lines in the spectrum of zinc were lengthened by the action of water upon the electrodes. It has now been proved beyond doubt that this peculiar variation in the spectra is caused by the cooling action of the water upon the negative electrode, which in effect is the same as a strengthening of the spark, since by heating the electrodes a reverse action is the result.

Alterations in the Spectrum of Carbon.—As already stated in the previous Reports, graphite electrodes have been generally employed for the production of spark spectra from solutions. A portion of the work in connection with this subject included an investigation of the effect of water and of saline solutions in varying the spectrum of carbon. It will of course be readily understood that as carbon is capable of combining with oxygen and nitrogen, that different spectra might be obtained by making one or other of these gases the atmosphere surrounding the electrodes, but it is not so easy to explain why graphite points should give two different spectra in air when dry, and a third spectrum, again different, when moist, the same spark conditions being maintained.

Three such spectra have been photographed, but without the aid of maps their peculiarities are not capable of exact description. The maps which were drawn were presented to the Royal Society, together with a communication on this subject, three months since, so that they are not at present available. It may be said, however, that the difference between the two spectra taken from dry electrodes in air consists of the omission of a certain number of the less refrangible lines, which lines have undoubtedly been identified with carbon.

Spectra of the Non-Metallic Constituents of Salts.—A long series of experiments has been made with the object of determining the non-metallic elements which are capable of yielding spark spectra when in combination with the metals. Fluorides, chlorides, bromides, iodides, sulphides, nitrates, sulphates, selenates, phosphates, carbonates, and cyanides yield nothing. On the other hand, hydrochloric acid solutions of arsenites and antimonates yield the spectra of arsenic and antimony. Borates and silicates in solution yield very characteristic spectra of the non-metallic constituents, but if the solutions be prepared from sodium salts the lines of the metal do not appear in the case of borates, and only the strongest sodium line ($\lambda = 3301$) can be observed in the spectra of silicates, even when concentrated solutions are used.

Line Spectra

BORON Wave-lengths	SILICON Wave-lengths
3450.1	2881.0
2497.0	2631.4
2496.2	2541.0
	2528.1
	2523.5
	2518.5
	2515.5
	2513.7
	2506.3
	2435.5

These are the first spectra of boron and silicon obtained from metallic salts.

In Messrs. Living and Dewar's map of the carbon spectrum (*Proc. Roy. Soc.* vol. xxxiii. p. 403), and in the list of the carbon lines and in the map of the iron spectrum (*Phil. Trans.* part I, 1883), a number of lines are given which are absent from the photographs of the spectrum of graphite published in the *Transactions of the Royal Dublin Society* and in the *Journal of the Chemical Society* (vol. xli. p. 90). Many hundreds of spectra taken between graphite poles have failed to show a trace of these lines, and as the spectra have been photographed under very various conditions, it is scarcely likely that the lines in question are really carbon lines. They have now been identified in the spectrum of silicon.

Living and Dewar's carbon lines		Silicon lines (Hartley)	
Spark ¹	Arc ²		
—	2881·1	...	2881·0
2541·0	2541·0
2528·2	2528·1	...	2528·1
2523·6	2523·9	...	2523·5
2518·7	2518·8	...	2518·5
2515·8	2515·8	...	2515·5
2514·0	2514·1	...	2513·7
2506·3	2506·6	...	2506·3
	2478·3	...	—
	2434·8	...	2435·5

From this it appears that, in the spectrum of the arc, carbon yields but one line in the ultra-violet, wave-length 2478·3. It is perhaps a little doubtful whether the line with wave-length 2434·8 is due to silicon or not.

The Spectrum of Beryllium.—The researches made for the purpose of this report have been useful in furnishing evidence leading to a determination of the probable position of beryllium among the elements. It has been proved that the spectra of metallic solutions are identical with those of the metals themselves, and it is therefore obvious that characteristic spectra may be obtained from concentrated solutions of nitrates or chlorides when metallic electrodes are not procurable.

It was resolved to photograph the spectrum of beryllium, as obtained from its chloride, in order to observe the character of its lines and the manner of their grouping. The following were the lines observed:—

SPECTRUM OF BERYLLIUM	
Wave-length	Description
3320·1	Strong, sharp.
3129·9	Very strong, extended.
2649·4	Strong, sharp.
2493·2	" "
2477·7	" "

The first two numbers differ slightly from those given in the *Journal of the Chemical Society* (June, 1883), but they are believed to be the more accurate. The previous measurements of the lines of beryllium were two given by Thalén (Watts's "Index of Spectra"), with wave-lengths 4487 and 4575, and two lines very close together given in Cornu's "Map of the Solar Spectrum," wave-lengths 3130 and 3130·4. It will be observed that in the spark spectrum only one line corresponding to the first of these is observed, viz. 3129·9. There is probably a difference in this case between the arc and the spark spectra, because there is no difficulty in distinguishing between two lines differing by 0·4 of a tenth-metre, and under various conditions two lines have never been observed at this point in the spark spectrum. On the other hand, such differences are by no means unusual.

Regarding the views held by Emerson Reynolds, Nilson and Pettersson, and Brauner on the subject of beryllium, however wanting in harmony they may be in detail, they at least agree in assigning a value not greater than 13·8 and not less than 9·2 to its atomic weight. The former number implies that the metal is a triad, the latter that it is a dyad. In the former case it must belong either to the series of elements of which aluminium, gallium, and indium are members, or to a sub-group of rare earth-metals, to which yttrium and scandium belong. In attempting to accommodate the element with a position in either series we are met by a serious difficulty, namely, that not only is the atomic weight out of keeping with the periodic law (a point which cannot be discussed here), but its spectrum is altogether different from the spectra typical of either class.

There is a periodic variation in the spectra of the elements as well as in their atomic weights and chemical properties, and we

cannot put the periodic law out of mind in considering the position of beryllium.

Now the spectra typical of the triad group, of which aluminium and indium are the first and third terms, consist of three pairs of lines harmonically related, the intervals between the individuals of each pair increasing with increased refrangibility of the rays in each spectrum, while the intervals between the individuals in each pair in different spectra increase with the increase of atomic weight. The interval between each pair of lines contains an isolated ray. As the atomic weight of beryllium is less than that of aluminium, it should have a spectrum in which the same grouping appears, but the intervals between the pairs of lines should be shorter, and the individuals of each pair should be closer together.

The lines of beryllium are not characteristically grouped like those of aluminium and indium; it cannot therefore belong to this series of elements. If we attempt to classify beryllium in a manner which accords with Nilson and Pettersson's views (*Proc. Roy. Soc.*, 1880, vol. xxxi. p. 37), the elements scandium and yttrium, with atomic weights 44 and 89 respectively, must yield spectra typical of the series, and the similarity between the spectra of the two metals, beryllium and scandium, must be exceedingly close. Now Thalén's spectra of scandium and yttrium, though both totally unlike the spectra of any other element, have many characters in common (*Kongl. Svenska Akademien Handlingar*, vol. xii. p. 4, and *Comptes Rendus*, vol. xci. p. 45); both spectra contain highly characteristic groups of lines in the orange and yellow, the lines or bands degrading towards the red, and the number of lines which have been measured are no fewer than 103 and 90 respectively.

From these two spectra that of beryllium is entirely different, as well in the character and grouping as in the number of the lines. Of the remaining rare earth-metals at present known, cerium is a tetrad, didymium is a pentad, and lanthanum a triad; their spectra are quite dissimilar from that of beryllium. In consideration of these facts it is impossible to classify the spectrum of beryllium along with the spectra of the rare earth-metals of the triad group.

Let us now consider the question of the dyad groups. On the assumption that beryllium has an atomic weight of 9·2, there is no difficulty in placing it at the head of the second series, in which position it stands in the same relation to the sub-groups Mg, Zn, Cd, and Ca, Sr, Ba, that Li occupies with regard to Na, K, Rb, Cs, and Cu, Ag, Hg. Its position will also be similar to that of B and of C in their relation to the triad and tetrad metals. The spectra belonging to Mg, Zn, Cd, have a very definite constitution; they consist of (1) a single line, (2) a pair of lines, (3) three to four groups of triplets, (4) a quadruple group, and (5) a quintuple group of lines. The intervals between the individual lines in their different groupings increase with the increase in the atomic weights of the elements. In fact these spectra present a considerable addition to the body of evidence in support of the view that elements whose atomic weights differ by an approximately constant quantity, and whose chemical character is similar, are truly homologous bodies, or, in other words, are the same kind of matter in different states of condensation (*Journal of the Chemical Society*, September, 1883, p. 390, *Trans.*). Their particles are vibrating in the same manner, but with different velocities. In the spectra of the metals Ca, Sr, Ba, successive pairs of lines are a strong feature, in addition to which there are some other groups in the spectrum of barium. The individuals of each pair are separated by smaller intervals the more refrangible the lines, and by larger intervals the higher the atomic weights. It cannot be said that the spectrum of beryllium is precisely similar in constitution to either of these groups of elements.

There is some slight resemblance in character to the spectrum typical of the calcium group, beryllium having two pairs of lines, the individuals of the first or less refrangible pair being separated by a greater interval than those of the second pair. It is a spectrum analogous to that of lithium, hence it was concluded that beryllium is the first member of a dyad series of elements to which probably calcium, strontium, and barium are more strictly homologous than magnesium, &c. It is to be understood that this is a conclusion drawn from one point of view only, and is open to correction or modification when fresh facts shall have been discovered, but so far the classification of beryllium among the dyads is confirmed and maintained by its position being in harmony with these spectrum observations. The metal is shown to be quite out of place among the triad elements.

¹ *Proc. Roy. Soc.*

² *Phil. Trans.*